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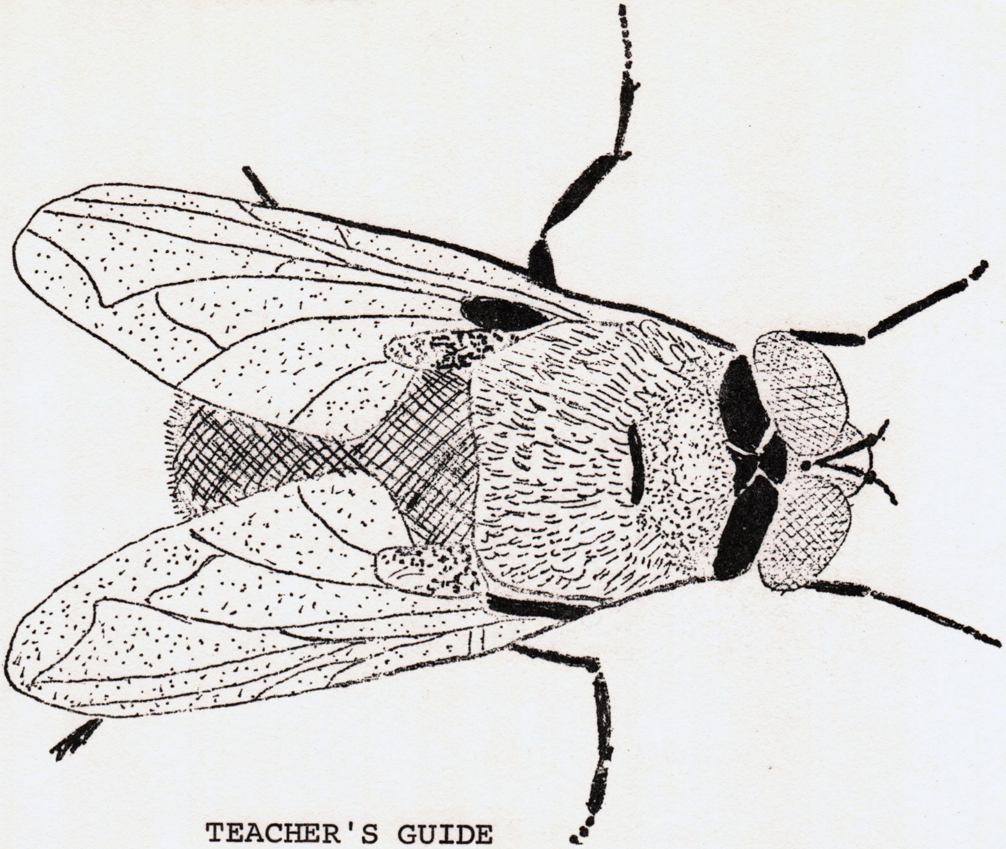
STERL



TEACHER'S GUIDE

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HUNTINGTON TWO COMPUTER PROJECT

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STERL

Teacher Material

Subject Area: Biology; Environmental Studies

Topic: The Sterile Male Technique in Insect Control

Grade Level: 9 - 12

Computer Language: BASIC

Abstract: STERL is a computer simulation designed to make possible an investigation of the effectiveness of two very different methods of pest control: 1) the use of pesticides, and 2) the release of sterile males, whether used singly or together in an integrated program. Our goal was to introduce an alternative to chemical control and to demonstrate the effectiveness of an integrated program that takes into account much more than the number of pests that can be eliminated with one application of pesticide.

For each run, the goal is to eliminate the one million male flies in a 10,000 square mile area. To do this you can use a pesticide on any day of the 75-day period, release up to one million sterile flies per day, or do a combination of both. When you have specified a pest control strategy, the computer will print out a graph of the number of flies present in the area each day of the 75-day period. By trying different measures and comparing the results, you can determine the effectiveness of different pest-control programs.

NOTE: FOR THOSE USING SMALLER COMPUTERS -- START STERL PAPER TAPE IN MIDDLE AFTER THE SECOND LEADER. THIS WILL DELETE THE INSTRUCTIONS, SO YOU MIGHT WANT TO LIST THE INSTRUCTIONS SEPARATELY AND MAKE COPIES OF THEM FOR YOUR STUDENTS.

SAMPLE RUN

```
                    CONTROL OF SCREW-WORM FLY POPULATION

INSTRUCTIONS (1=YES, 0=NO)? 1

YOUR GOAL WILL BE TO ELIMINATE THE ONE MILLION MALE
FLIES NOW IN YOUR 10000 SQUARE MILE AREA, THUS DESTROYING
THE TOTAL FLY POPULATION.  YOU MAY USE A PESTICIDE,
RELEASE STERILE MALE FLIES, OR BOTH.  INDICATE THE TYPE
OF CONTROL PROGRAM YOU WANT BY TYPING IN THE APPROPRIATE
RESPONSES TO THE FOLLOWING QUESTIONS:

'PESTICIDE?'
  0= NO PESTICIDES.
  1= PESTICIDES ON SPECIFIED DAYS.  INDICATE
     THESE DAYS BY TYPING A DAY NUMBER (BETWEEN 1 AND 75)
     NEXT TO EACH '?' THAT APPEARS; TYPE 0 WHEN FINISHED.

'STERILE FLIES?'
  0= NO STERILE FLIES.
  1= STERILE FLIES WILL BE RELEASED.  COMPUTER WILL
     ASK 'HOW OFTEN?'  TYPE 1=DAILY OR 2=CERTAIN DAYS
  IF 1, SPECIFY NUMBER OF FLIES EACH DAY (UP TO 1000000),
        THE FIRST DAY OF THE PERIOD, AND THE LAST DAY
        (BETWEEN 1 AND 75 DAYS).
  IF 2, FOR EACH DAY SELECTED, SPECIFY THE DAY NUMBER
       (BETWEEN 1 AND 75) AND THE NUMBER OF STERILE FLIES
        (UP TO 1000000).  USE A NEW LINE FOR EACH DAY.
        TYPE 0,0 WHEN FINISHED.

**********

PESTICIDE (1=YES, 0=NO)?  1
WHICH DAYS
? 1
? 0

STERILE FLIES (1=YES, 0=NO)? 1
HOW OFTEN (1=DAILY, 2=SELECTED DAYS)? 1
HOW MANY PER DAY? 100000
FROM WHEN, TO WHEN? 2,75
```

```
              MILLIONS OF NORMAL ADULT MALE FLIES
     0        .2        .4        .6        .8         1
DAY  I---------I---------I---------I---------I---------I
 0  I                                                  *  1.000000E+6
 1  I     *  100000
 2  I                      *  449490
 3  I                                  *  673776
 4  I                                        *  803252
 5  I                                      *  756018
 6  I                                    *  729439
 7  I                                   *  709264
 8  I                                   *  694553
 9  I                                  *  683936
 10 I                                  *  676357
 11 I                                  *  671004
 12 I                                 *  667261
 13 I                                 *  664675
 14 I                               *  619643
 15 I                             *  577473
 16 I                           *  543133
 17 I                          *  513161
 18 I                        *  484279
 19 I                      *  446728
 20 I                     *  413758
 21 I                   *  386458
 22 I                          *  523585
 23 I                            *  564634
 24 I                            *  562284
 25 I                           *  543579
 26 I                          *  528813
 27 I                          *  521538
 28 I                          *  520445
 29 I                          *  524472
 30 I                           *  532763
 31 I                           *  549530
 32 I                            *  569571
 33 I                              *  591564
 34 I                            *  553062
 35 I                          *  515062
 36 I                        *  483245
 37 I                       *  454919
 38 I                     *  427450
 39 I                   *  386459
 40 I                  *  352243
 41 I                *  324627
 42 I                       *  467484
 43 I                          *  511823
 44 I                         *  508747
 45 I                        *  487595
 46 I                       *  468690
 47 I                       *  458813
 48 I                       *  457173
 49 I                       *  462858
 50 I                        *  475326
 51 I                         *  503112
 52 I                           *  539213
 53 I                             *  581056
 54 I                           *  543340
 55 I                         *  503226
 56 I                       *  468573
 57 I                      *  437294
 58 I                    *  407364
 59 I                  *  362420
 60 I                *  325713
 61 I               *  296969
 62 I                       *  458149
 63 I                         *  506672
 64 I                         *  499903
 65 I                        *  473169
 66 I                      *  447112
 67 I                      *  430788
 68 I                     *  424392
 69 I                     *  427523
 70 I                      *  440224
 71 I                        *  477378
 72 I                           *  530563
 73 I                              *  595228
 74 I                            *  557851
 75 I                          *  514578
     I---------I---------I---------I---------I---------I


COST OF FLY CONTROL: $ 174  THOUSAND DOLLARS

ESTIMATED DAMAGE: $ 2.556255  MILLION DOLLARS

ANOTHER RUN (1=YES, 0=NO)? 1
```

THE STERL PROGRAM

I. How the model works

Based on the assumptions listed (see *RESOURCE HANDBOOK*, pp. 10-11), the STERL program operates in the following way:

The initial population of the area is one million normal male flies, equally distributed over each of the 17 days of adult life. This is the maximum capacity of the area. (There is, by assumption, always an equal number of females present, but our convention will be to specify the size of the population by the number of males only.)

The size of the population on each of the 75 days is calculated in the following sequence of events. The first event which occurs is the death of all 17-day old adults, both normal and sterile. Next, new normal adults emerge from the pupal state, 13 days after the eggs are laid. At this point sterile males are released if the user has specified their release on that particular day. Thus the total population on any day is equal to the population from the preceding day, plus newly emerging flies, plus newly added steriles, minus 17-day old steriles and normals.

This total number is compared with the carrying capacity of the area: one million male flies. If there are over a million male flies, the excess number of flies emigrate out to the area in proportion to the distribution of normal:sterile; if there are less than a million, a number of flies equal to 10% of the difference immigrate into the area. After emigration or immigration has occurred, a pesticide is applied - assuming that the user has specified its application on that day. The pesticide is effective only on the day of application, eliminating 90% of the adult fly population. (*NOTE: THE PESTICIDE IS NOT* DDT.) The number of adult flies remaining is carried over to the next day.

After application of the pesticide, the remaining 7-day old females lay their eggs. Each adult female is capable of depositing 250 eggs, but the total number of fertile eggs is determined by the relative proportion of normal males and sterile males. (The mating efficiency of sterile males is only 25%. See *RESOURCE HANDBOOK*, p. 11.) Of those eggs which are fertilized, only a small percentage reach adulthood. This percentage depends on the normal adult population in the area at the time, and is determined by a linear equation that specifies a 1% survival rate when the population is one million, and a 4% survival rate when the population is 100,000 - or 10% of the carrying capacity. This percentage times the number of fertilized eggs laid constitutes the number of adult flies emerging from the pupal state 13 days later.

II. Running the program

You have a number of options with regard to using either technique to eliminate the male fly population. If you decide to use a pesticide, you must indicate on what days you want a pesticide applied, by typing in the day numbers. If you decide to release sterile males, you can either: 1) release the same number continuously over a certain period, or 2) release the same or different numbers on specific days only. In the first case you have to input the number of flies to be released, the first day of the period and the last day. In the second case, the computer will request the individual day numbers as well as the number of sterile flies to be released on each specified day. The second method must be used whenever you wish to vary the number of sterile flies released.

The computer will then print a graph of the number of normal adult male flies in the area over the 75-day period, with each day's population printed next to the appropriate point. *(NOTE: IF THE NUMBER OF FLIES IS LESS THAN 10,000, ITS PLOT WILL BE 0.)* Following this graph the computer will give the cost of the control program, as well as the estimated dollar damage caused by the flies in your area. By examining the effect of each strategy on the fly population and by comparing the effects of different strategies, you can determine optimal combinations of pesticide application and sterile fly releases.

III. The cost factor

The calculation is determined by the following individual costs:

Pesticides: $10/square mile for the insecticide
and its application

Sterile male releases: 1¢ for each fly released.

These figures for the total cost can be compared with the amount of damage done to livestock by the screw-worm fly in the Southwest each year: approximately $25 million. In STERL it is estimated that the damage each fly causes is equal to (1/15)($1)/day/fly.

SUGGESTIONS FOR USING *STERL* IN THE CLASSROOM

I. PREPARATORY ACTIVITIES

You may find class discussions about the following topics helpful in providing your students with the background for running *STERL*.

a) Different categories of pest control (see *RESOURCE HANDBOOK)*. Give examples from each group, emphasizing that the term "pest" is not reserved for insects and that pesticides are not the only method of control.

b) Pesticides
Review the development of the synthetic organic pesticides during World War II and the rise in their use after the war. How effective are these chemical poisons? Why the current disillusionment with them? What are the properties of two main groups of synthetic organic pesticides: the chlorinated hydrocarbons and the organophosphates, that make them valuable as pesticides? What ecological dangers and imbalances can result from the indiscriminate use of pesticides, especially the chlorinated hydrocarbons? This discussion should generate the realization that more effective and more selective methods of pest control are needed.

c) Sterile Male Technique
You might use Knipling's article to introduce the sterile male technique as a method of biological control. (Emphasize, however, that the method is not limited to the screw-worm fly, and that the screw-worm fly is used in this simulation because it was the first pest species to be controlled by this technique.) The article also provides an excellent account of the technical difficulties involved in implementing the technique. Indicate the effectiveness of the technique as demonstrated in the initial field studies on the screw-worm fly.

d) Screw-Worm Fly
Knipling's article contains information about the life cycle and habits of the screw-worm fly, as well as a discussion of its status as a major parasite of livestock.

e) List the major assumptions and explain the operation of the *STERL* program. Be sure that the students understand the options they have in using pesticides and/or sterile fly releases, and the format for inputting their choices into the machine. Discuss and formulate different control strategies to be tested.

II. RUNNING THE PROGRAM

We suggest trying the following control strategies to obtain some basic information about the effects of pesticides and sterile male releases on the fly population:

Use of pesticides alone.

Use of sterile male releases alone; be sure to try different numbers of flies.

Use of both methods concurrently and at different times, and in different combinations. (The two methods do not have to be used equally.)

Arranging to stop control measures after a pest population has reached zero.

The program can be revised to show the effects of different pesticides, different survival rates for the larvae, different rates of immigration or emigration, enhanced mating competitiveness of sterile flies, etc., by making the appropriate changes in the equations (see *RESOURCE HANDBOOK)*. In the same way, the program can be revised to demonstrate (theoretically, of course) the effectiveness of the sterile male technique on other pest species, provided you have the necessary information concerning their life cycles and mating habits.

You may want to divide the class into three equal groups. Assign one group the title *ARDENT ENVIRONMENTALISTS*, one group *TEXAS CATTLEMEN*, and the remaining group *REASONABLE SCIENTISTS*. Tell each group to determine the best method of fly control, keeping their personal interests in mind. Give each group several days to find an appropriate answer. Tell each group of students to select a spokesman to defend their control program before the entire class.

III. STUDENT MATERIAL

The background materials in the *RESOURCE HANDBOOK* have been written with the student in mind. You might assign your students certain readings from the *RESOURCE HANDBOOK*, in addition to the material in the *STUDENT MANUAL*, as preparation for running *STERL*.

IV. FOLLOW-UP DISCUSSION QUESTIONS

1) Can a pesticide alone eliminate a fly population? If so, how? What effects might this have on the environment?

2) Why does the pesticide decrease in efficiency as you use it over an extended number of days?

3) How effective are sterile fly releases alone in the control of the screw-worm fly? What is the proportion of sterile males that must be released to start a downward trend in the population? Why is it important that the number of normal flies be decreased rapidly in the early stages of the control program?

4) Which strategies did you find most effective in controlling or eliminating the fly population? Was integrated control, or the use of both methods more effective than the use of either method by itself?

5) What happens in an area where the fly has been eliminated and control measures are lifted? Is it ever possible to eliminate a pest from an area for good?

6) Why is the regular release of sterile males combined with the regular use of pesticides ineffective?

7) Give some of the reasons for small fluctuations in the fly population when the trend is generally downward.

8) What factors must be considered in deciding upon the method or methods to be used in an insect control program?

9) When is it possible to use the sterile male technique? What are the advantages of the technique over conventional pesticides?

10) Discuss the use of the sterile male technique for other pest species, such as the boll weevil and the tsetse fly. What difficulties must be solved before the technique can be implemented for these species?

11) On the basis of what you have learned, propose an effective and economically feasible program for controlling the screw-worm fly.